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How will electrification impact our grids?

Georeferenced Methodology for Urban Impact Assessment.

Online
17/10/2024

DRIVE2X

The authors are thankful for the European Commission funding from project DriVe2X, grant No. 101056934

Need for decarbonization

- Reduction of greenhouse gas emissions
- Transformations in urban environments and energy consumption

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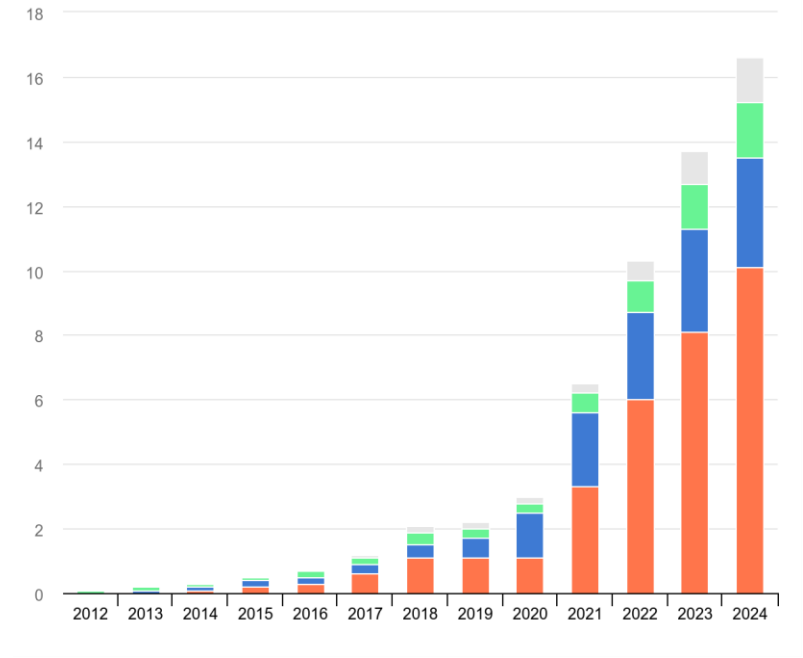
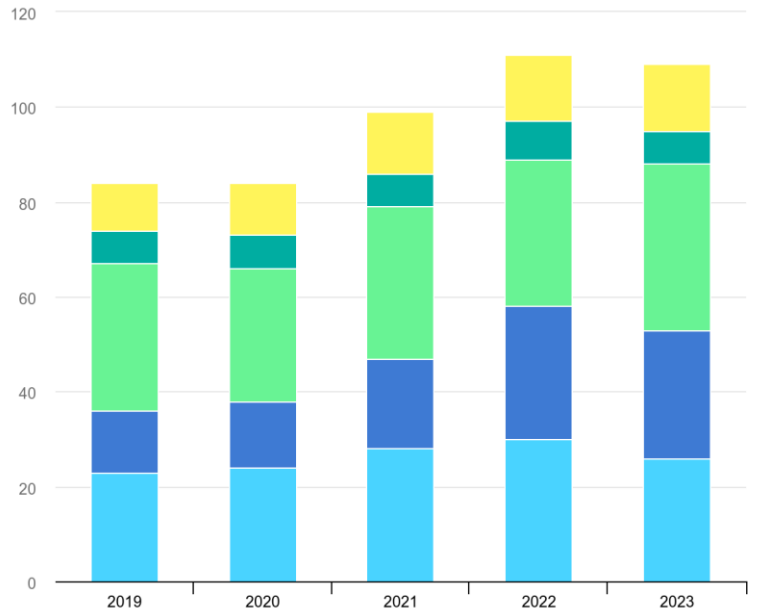
Electric vehicles and heat pumps will play a key role in the decarbonization of the urban environment



EV sales evolution

IEA (2024), Electric car sales, 2012-2024, IEA, Paris https://www.iea.org/data-and-statistics/charts/electric-car-sales-2012-2024, Licence: CC BY 4.0



Heat pump sales evolution

IEA (2024), Heat pump sales by country or region, 2019-2023, IEA, Paris https://www.iea.org/data-and-statistics/charts/heat-pump-sales-by-country-or-region-2019-2023, Licence: CC BY 4.0

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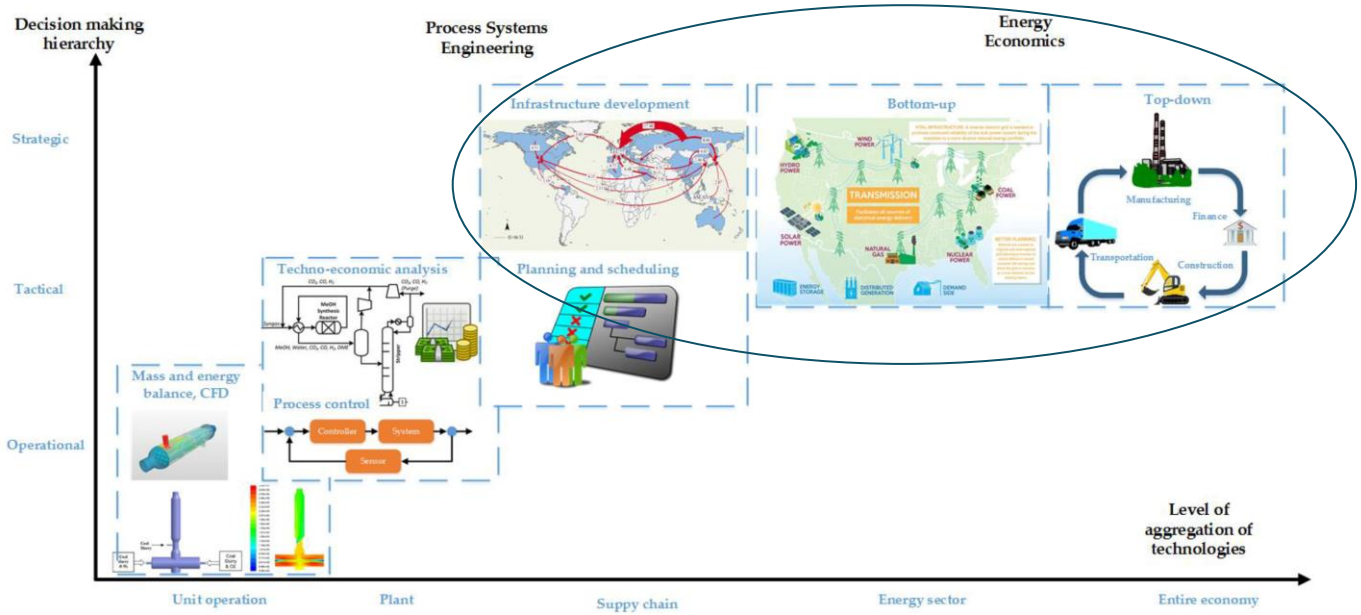
Our electricity infrastructure must be ready to accommodate transition

High complexity transition

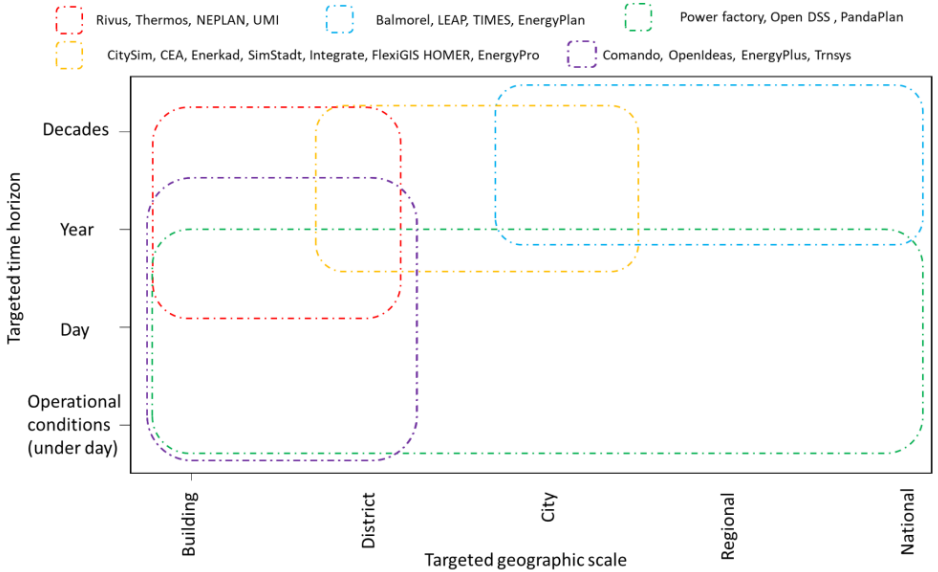
Energy Systems Modelling :

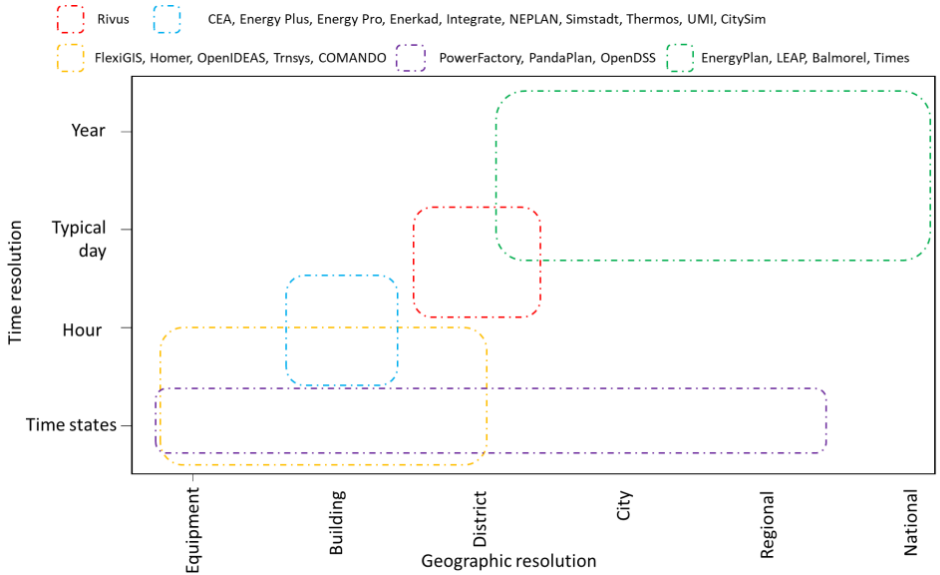
- Simulation and analysis of complex systems
- Long-term planning and design



Subramanian, A.S.R.; Gundersen, T.; Adams, T.A., II. Modeling and Simulation of Energy Systems: A Review. Processes 2018, 6, 238. https://doi.org/10.3390/pr6120238

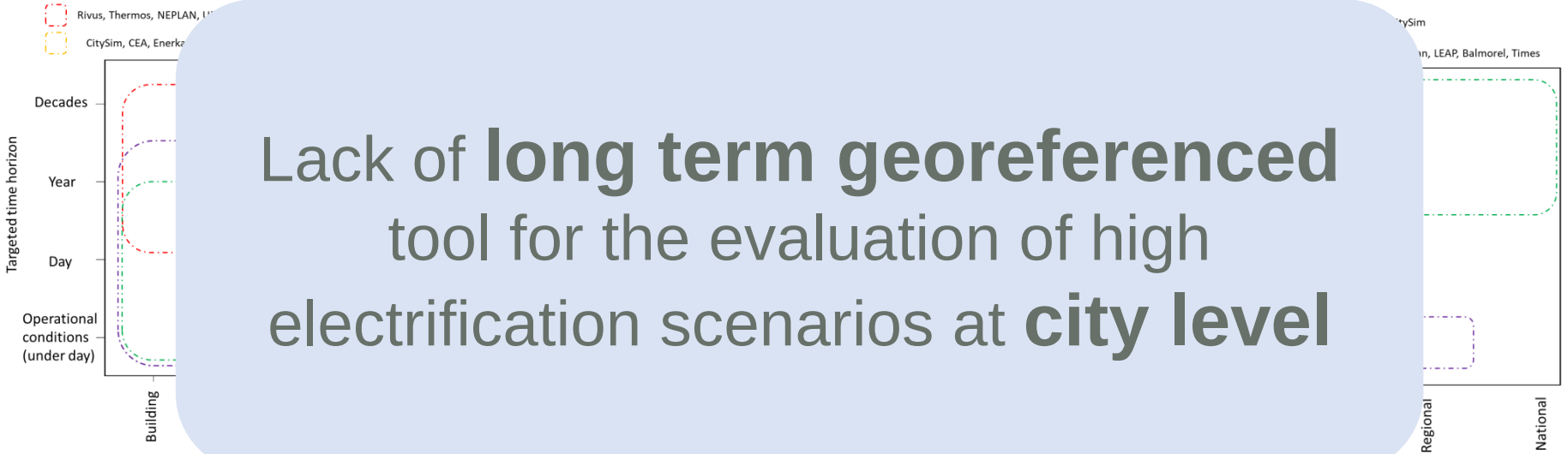
Clear need for planning ahead





J. Pedrero, E. Arrizabalaga, D. García, N. Hermoso, I. Muñoz, and P. Hernández, “Review of georeferrenced energy planning tools and methods for the assessment of decarbonization scenarios,” in 9th International Conference on Smart Energy Systems, 2023, pp. 12–13. [Online]. Available: https://www.researchgate.net/publication/378527110

Clear need for planning ahead

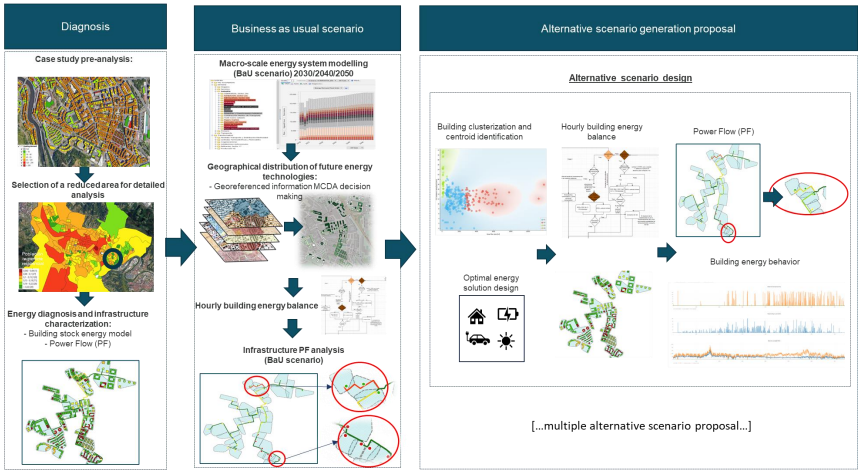


Lack of **long term georeferenced** tool for the evaluation of high electrification scenarios at **city level**

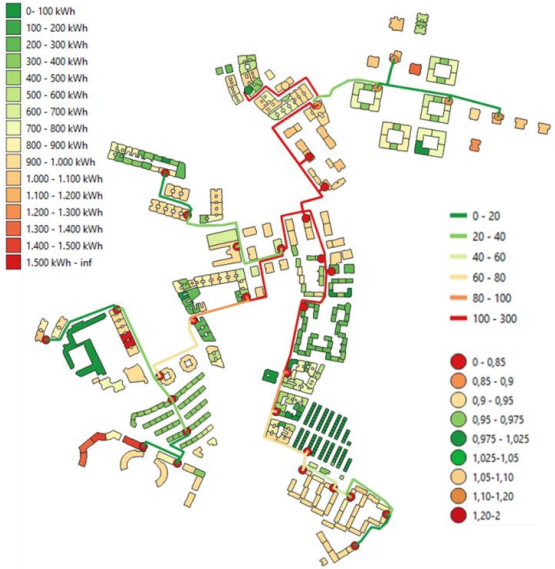
J. Pedrero, E. Arrizabalaga, D. García, N. Hermoso, I. Muñoz, and P. Hernández, “Review of georeferrenced energy planning tools and methods for the assessment of decarbonization scenarios,” in 9th International Conference on Smart Energy Systems, 2023, pp. 12–13. [Online]. Available: https://www.researchgate.net/publication/378527110

Research objective

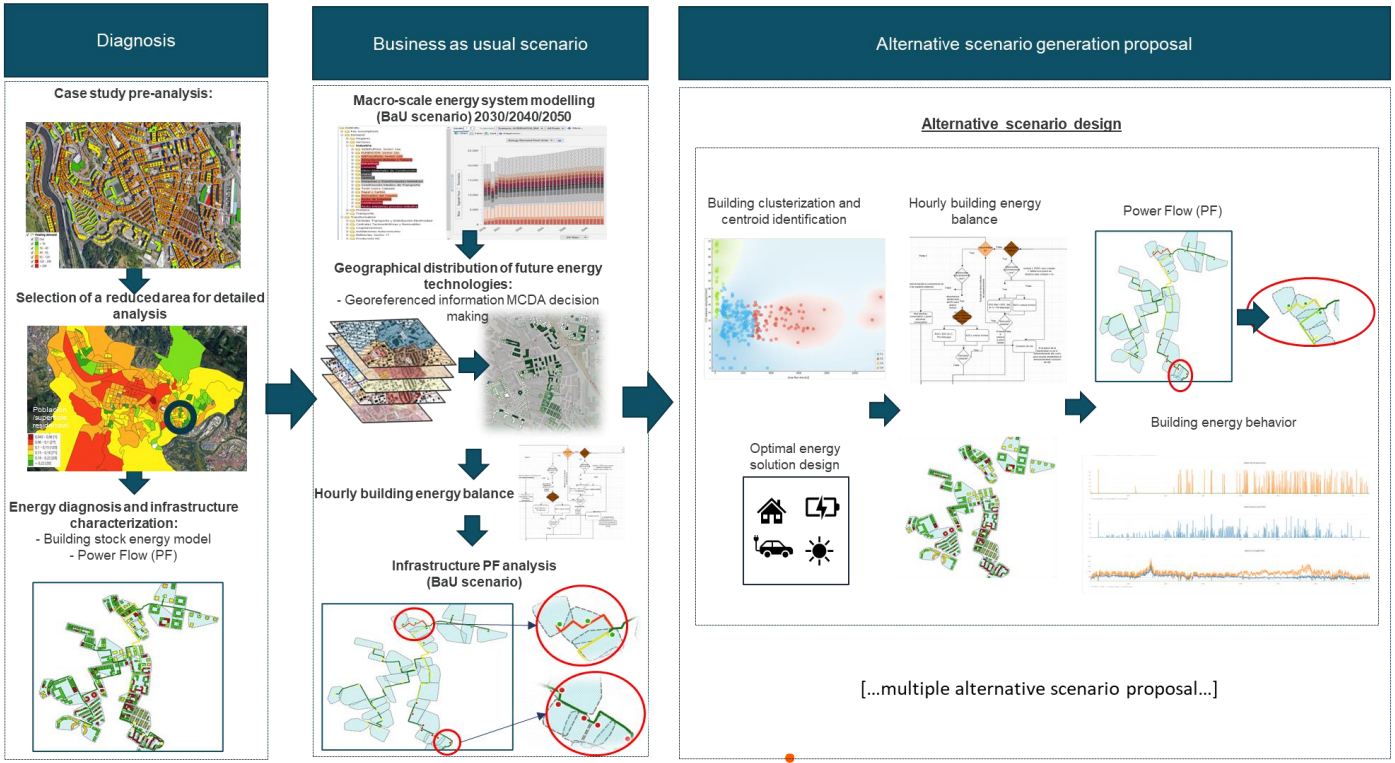
Development of methodology for the geo-referenced assessment of high electrification scenarios



Demonstration of the methodology through a case study



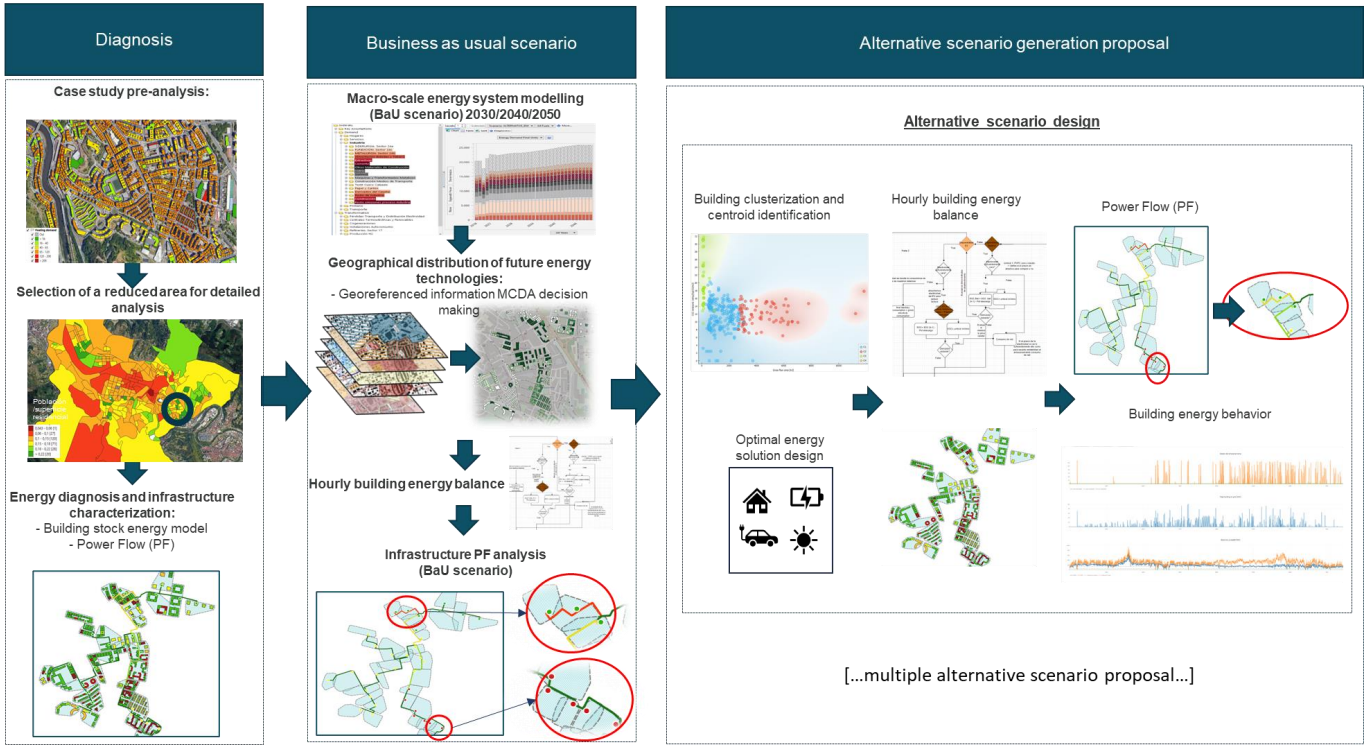
Overall methodology



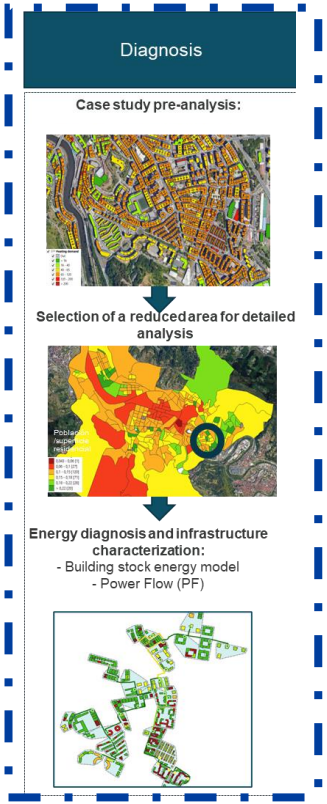
Modelling techniques used

1. Building stock energy model
2. City energy strategy integrated model
3. Georeferenced multi criteria decision making
4. Power flow calculation
5. Representative building characterization
6. Building energy system design optimization
7. Hourly balance calculation

Methodology workflow



Methodology workflow



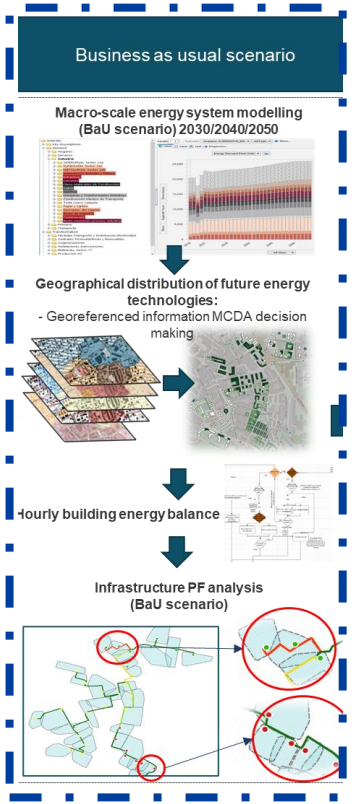
Diagnosis:

Represents the current status of the case study

Steps:

1. Case-study comprehension and pre-analysis
2. Selection of a reduced area for detailed analysis
3. Building stock energy model
4. Energy balance calculation
5. Power Flow Calculation

Methodology workflow



Business as Usual:

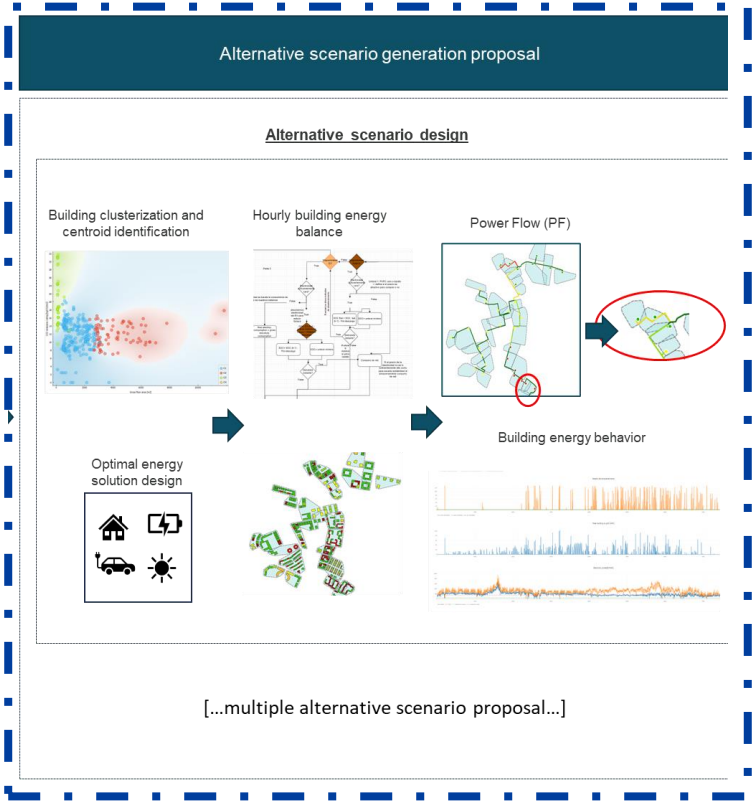
Represents where we are going

Serves as a reference framework

Steps:

1. City energy strategy integrated model
2. Georeferenced multi criteria decision making
3. Energy balance calculation
4. Power Flow Calculation

Methodology workflow



Alternative scenario proposal:

Represents where can we go if we make changes

Steps:

1. Representative building characterization
2. Building energy system design optimization
3. Energy balance calculation
4. Power Flow Calculation

Case study: Bilbao

Selected area:

Bilbao's residential neighborhood

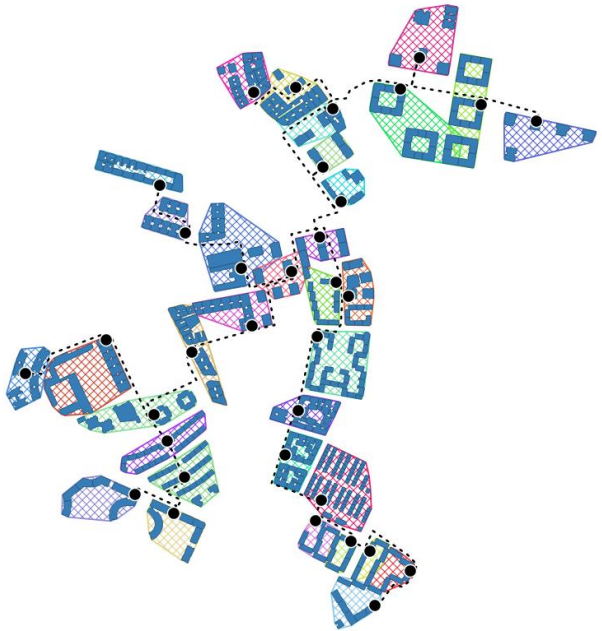
Main selection criteria: data availability

		Construction period				
Main building use	No data	**Pre-1944**	**1945-1969**	**1970-1979**	**1980-2006**	**Total**
No data	3					3
Commercial		1				1
Education				2	1	3
Hotel		1				1
House		100	1			101
Office			1		1	2
Apartment buildings		11	206	71	56	344
Sport facilities					1	1
Total	**3**	**113**	**208**	**73**	**59**	**456**

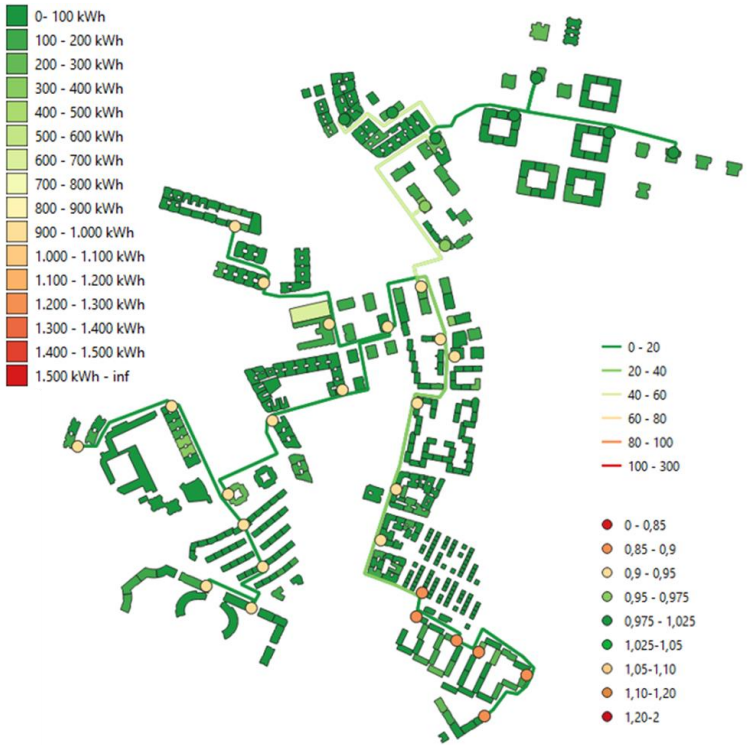
Mainly natural gas

Electricity consumption [GWh]	Heating consumption [GWh]	DHW consumption [GWh]	Cooling consumption [GWh]
26,8	23,4	12,9	0

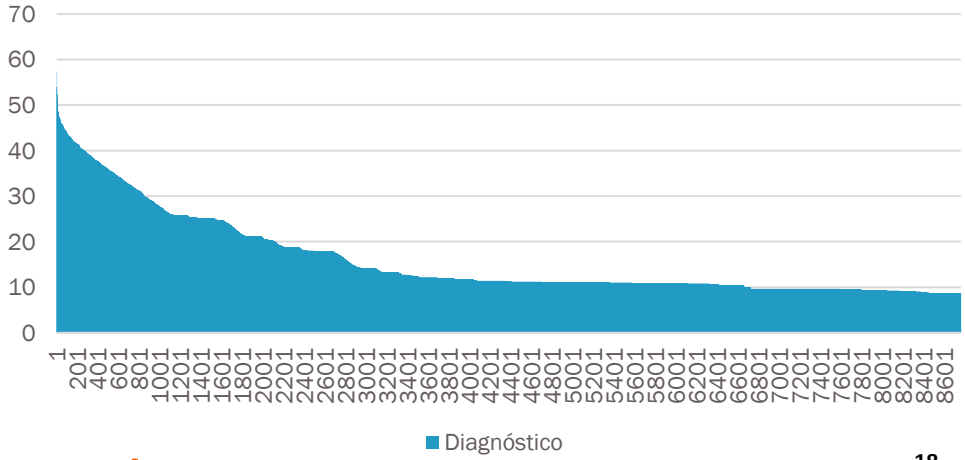
Synthetic network build due to lack of data availability:
modified IEEE 34-bus



Diagnosis



	Diagnosis
Maximum line loading (%)	57,35
Average line loading (%)	0,874

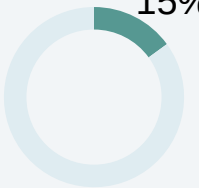


Scenario proposal

Business as usual:

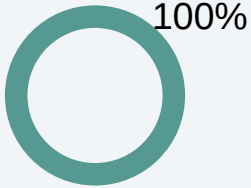
National Energy Plan 2030

Electric vehicle



Net zero 2050 through electrification

Electric heating



Electric heating

Scenario proposal

Alternative scenario

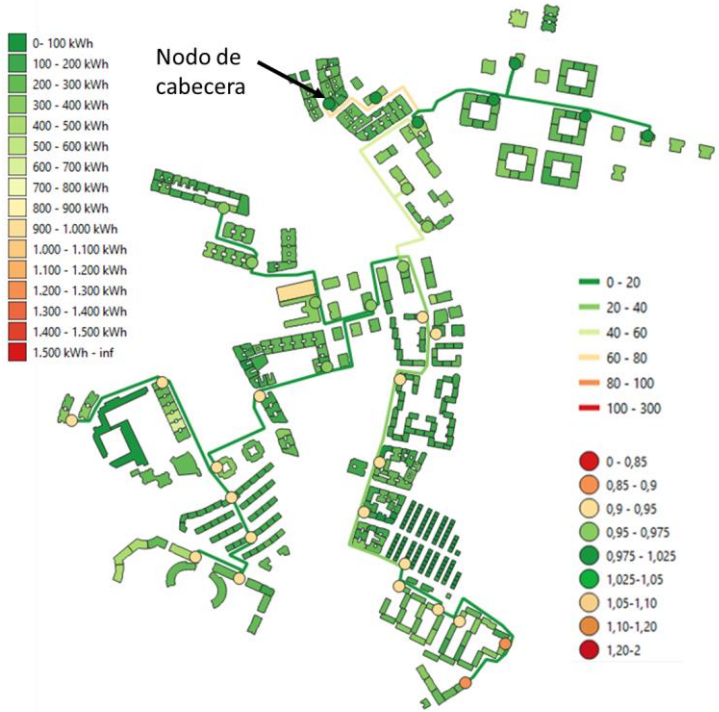
Net zero 2050
No Batteries

-100% EV → night charge
- Heating through HP
- PV generation

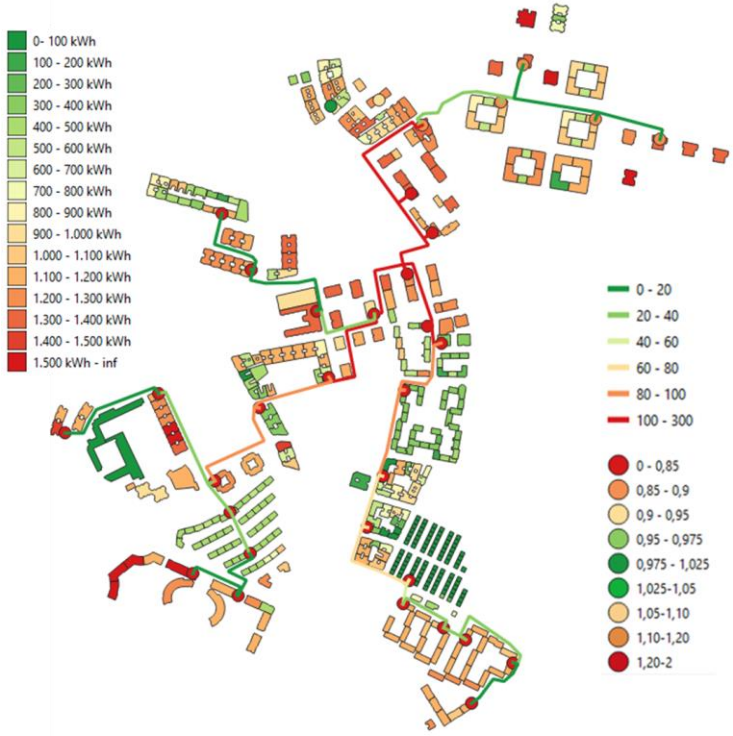
Net zero 2050
Batteries

-100% EV → night charge
- Heating through HP
- PV generation
- Optimized battery
(optimization criteria:
minimize electricity bill)

Scenario results

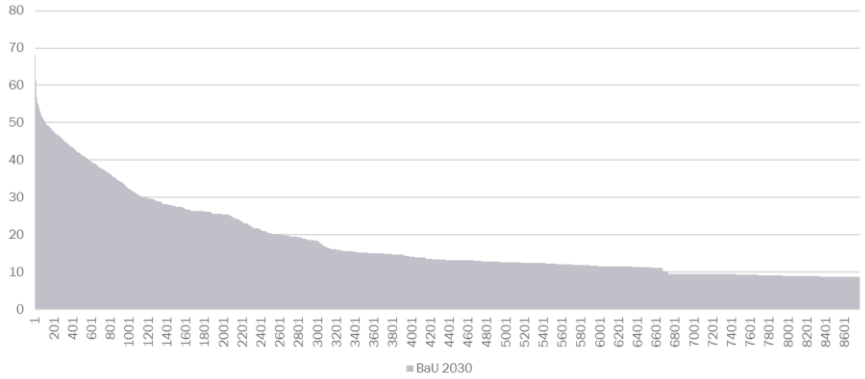


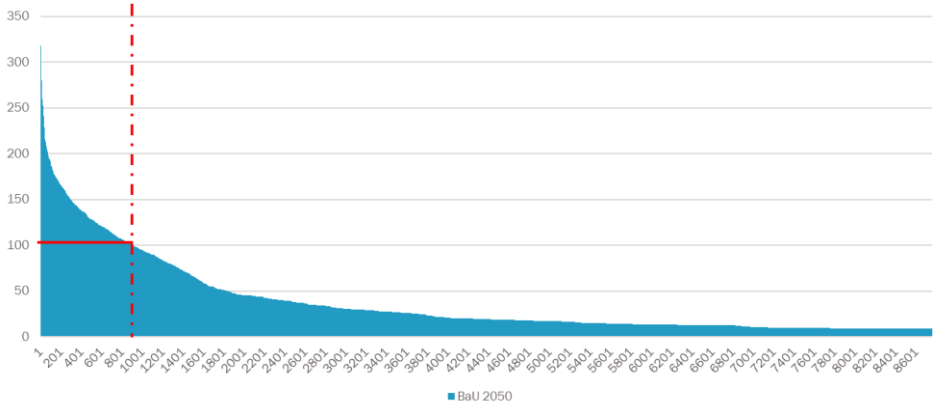
2030



2050

Scenario results

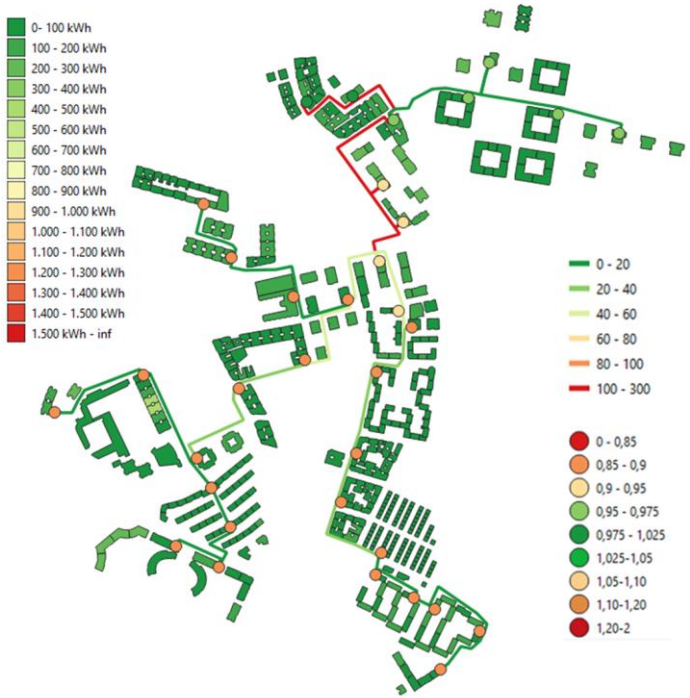




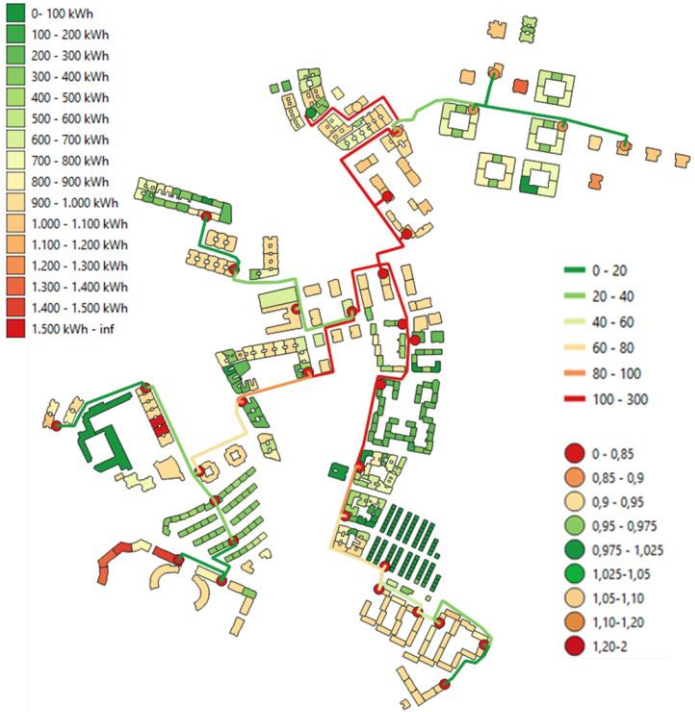
2030

2050

Scenario results

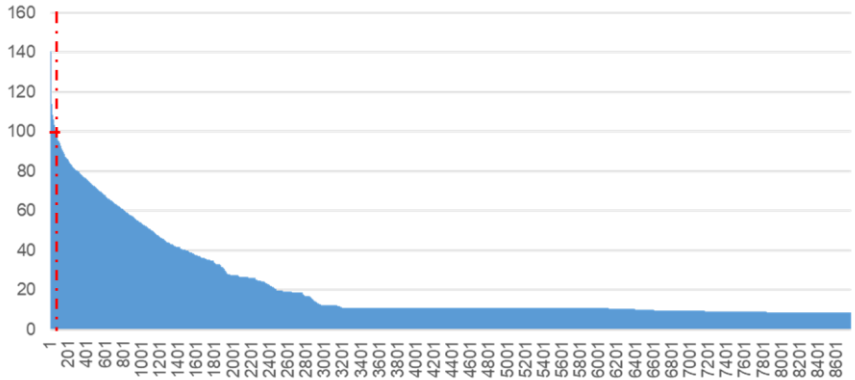


2050 No Batteries

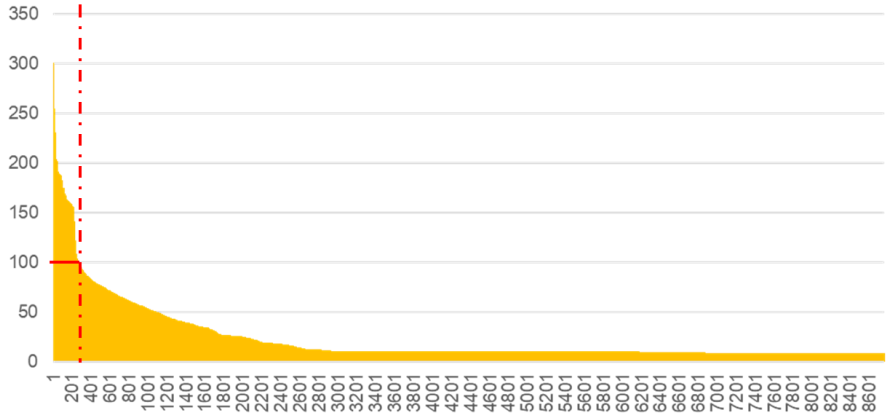


2050 No Batteries

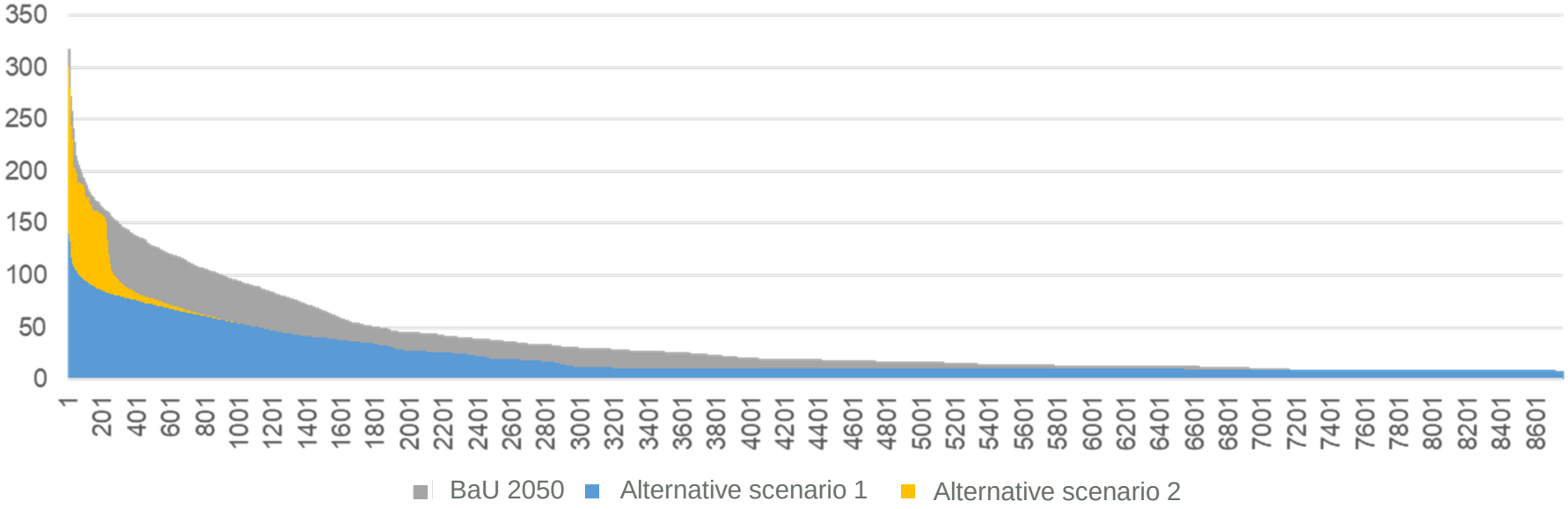
Scenario results



2030



2050



	BaU 2050	Alternative scenario 1	Alternative scenario 2
Grid electricity consumption	59,7GWh	28,8 GWh	30,2 GWh
Percentage compared to base year	223%	107%	113%

Main conclusions

- Alternative scenarios: successfully reduce grid load
- Essential elements for climate neutrality:
  - Heat pump → high efficiency levels
  - Incentives for vehicle charging during off-peak hours
- Self-managed batteries: new challenge for the grid
  - Need for regulation that takes prosumers and operators into account

Main conclusions

- In the short term (2030), electrification of mobility is **manageable** for the grid infrastructure.
- In the long term (2050), full electrification could **overload the grid**, with consumption exceeding 300% of capacity.
- Adapting regulatory and incentive schemes for flexibility systems is a major challenge

To know more:

https://drive2x.eu/

SES conference 2023: Smart Energy Systems – international conference
Review of georeferrenced energy planning tools and methods for the assessment of decarbonization scenarios (1)

EEM24 conference: eem24.khas.edu.tr – EEM24
Methodology for the geo-referenced urban-scale assessment of high electrification scenarios (2)

Sustainable Cities and Society
From rooftops to roads: Bilbao's geospatial solar and EV fusion
https://doi.org/10.1016/j.scs.2024.105290 **(3)**

(1)

(2)

(3)

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